Coating Condition Assessment of the Foresthill Road Bridge Auburn, California

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April 22, 2009

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JN280510
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INTRODUCTION

KTA-Tator, Inc. (KTA) was requested by Placer County to perform an assessment of the coatings applied to the Foresthill Road Bridge in Auburn, California. The assessment was deemed necessary since the bridge had not been painted in approximately forty years. Appropriate methods for remediation were desired. Mr. Ray Tombaugh, KTA Senior Consultant, was responsible for performing the assessment (August 6 through 10, 2008) and preparing this report.

SUMMARY

The coatings applied to the Foresthill Road Bridge are providing good corrosion protection in all areas except the top chord and deck support lateral ends on the northside of the bridge between Bays 5 and 21. At these locations, there is a moderate amount of pinpoint rusting. However, the corrosion is only in its initial stages with no section loss or pitting evident. In fact, pitting or section loss was not observed at any of the locations on the bridge that were examined. While the coating is over thirty-five years old, with the exception of the underside of the decking, it is still in place overall. The underside of the decking is experiencing significant areas of intercoat delamination, but no visible corrosion.

Three options are available for addressing the coatings on this bridge. The first involves complete coating removal; the second involves spot repairs only; and the third involves no action at this time. Complete coating removal and replacement (Option 1) will result in the application of a system with a new design life that will provide corrosion protection for over thirty years. Spot repairs alone (Option 2) will result in a seventeen year extension of the system until complete coating removal and replacement is required. If no painting is performed (Option 3), the existing coating can still be expected to last for another 10 years before complete coating removal and replacement is required. If Options 2 or 3 are selected, complete coating replacement should be scheduled in approximately 10 years.

Lead and other toxic metals (cadmium and chromium) have been found in the coatings. As such, surface preparation operations will have to be accomplished in accordance with OSHA and EPA regulations and within a containment system to protect the public, environment, and workers.

Complete coating removal and replacement (Option 1) is the preferred option for rehabilitating the bridge. Abrasive blast cleaning to SSPC-SP 10, “Near White,” is required. As an alternative to control dusting, wet abrasive blast cleaning or water jetting with abrasive injection could also be considered, as long as all mill scale, rust, and old paint are completely removed.

The prepared surfaces should be coated with a conventional organic zinc/epoxy/urethane system. The cost to complete this option is estimated at approximately $20,000,000.00.

Spot repairs (Option 2) would be performed by localized pressure water cleaning or by solvent cleaning in accordance with SSPC-SP 1, “Solvent Cleaning.” At the completion of the cleaning process, power tool cleaning in accordance with SSPC-SP 15, “Commercial Grade Power

Tool Cleaning," is required to prepare the rusted areas. All edges of existing intact coating should be feathered smooth. This will be satisfactory for all of the bridge surfaces except the underside of the decking and the top chord and deck support lateral ends on the northside of the bridge between Bays 5 and 21. In these locations, complete coating removal and replacement are necessary. Spot repair would not be cost effective in this area.

A surface tolerant epoxy should be used to spot prime the prepared bare steel, overlapping onto the existing feathered edges. Some lifting of the coating at the edges of the repairs may occur, which will have to be removed by scraping followed by the localized reapplication of the epoxy. A finish coat of polyurethane can then be spot applied to the primed surfaces. The cost to complete this option is estimated at approximately $1,800,000.00.

BACKGROUND

The Foresthill Road Bridge is located approximately 1 mile east of Interstate 80 at the Auburn Ravine/Foresthill Road exit in Placer County. The bridge stands 730-feet over the American River. The structure consists of a steel deck-truss measuring 2,428-feet from beginning to end of the bridge. The span lengths are 639-feet, 862-feet, and 639-feet, respectively from west to east. The structure is approximately 130-feet deep at the piers and 50-feet deep at the abutments. Approximately 1,000,000 square feet of paintable surface are present.

The bridge was constructed in the early 1970's and has not been repainted since that time. The County of Placer is responsible for maintaining the bridge and is currently undertaking a seismic retrofit project along with consideration of repainting.

FIELD INVESTIGATION

The field investigation was performed on August 6 through 10, 2008 and consisted of visual assessments of corrosion and coating deterioration, chalk assessments, adhesion tests, substrate examinations, dry film thickness measurements and soluble salt testing. Samples were removed for laboratory analysis to identify the generic type of coating and the concentration of lead, cadmium and chromium.

The majority of the assessment was performed from a snooper[1] along both sides of the bridge. Inspections using the snooper were limited to a maximum of approximately 70 feet below the level of the bridge deck. As such, assessments at the western expansion joint (lower chord) were performed from the bridge itself, as the distance was greater than 70 feet. Likewise, assessments performed at the western bearing were performed from the pier using a 16-foot extendable ladder.

The following assessments were made:

[1] A snooper truck is a reticulated crane that is installed on a flat bed truck that can reach over the side of a bridge to provide access to the underside.

- **Chalking** – Chalk assessments were performed in accordance with ASTM D4214, Method C, “Standard Test Method for Evaluating the Degree of Chalking of Exterior Paint Films.” The procedure is performed by moistening the fingertip and making one continuous rub 2″ to 2.5″ long. The material that accumulates on the finger is then compared to a pictorial reference standard. Chalking is evaluated on an even scale between 8 and 2, with 2 being the heaviest chalking.

- **Rusting** – Rusting was evaluated in accordance with SSPC-VIS 2, “Standard Test Methods for Evaluating the Degree of Rusting on Painted Surfaces.” The standard quantifies the degree of rusting on painted steel surfaces according to a 0 to 10 scale based on the percentage of visual rust present on the surface. A rating of 0 represents greater than 50% of the surface containing rust and a rating of 10 represents less than or equal to 0.01% of the surface containing rust. The distribution of rust is classified as spot rust, general rust, or pinpoint rust. Rust staining on the surface of the coating is excluded from the assessment.

- **Adhesion** – Adhesion tests were conducted in accordance with ASTM D3359, “Standard Test Methods for Measuring Adhesion by Tape Test,” and ASTM D4541, "Standard Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers."

  – ASTM D3359 involves making an X-scribe in the paint film. An adhesive tape (Permacel 99) is then applied to the scribe and lifted off of the surface. Adhesion is rated according to the amount of coating removed by the tape on a scale of 0A to 5A, with 5A being best.

  – ASTM D4541 involves attaching a pull stub to the coating using an epoxy adhesive and then applying a perpendicular load to the attached pull stub. A fixed alignment adhesion tester manufactured by Elcometer, Inc. was used. The test determines the greatest perpendicular force that a known surface area can bear before a plug of the coating is detached.

  – Selective probing with a knife was also performed in some areas.

- **Dry Film Thickness** – Film thickness measurements were obtained using a Positector 6000 FN3 Type II gage in general accordance with ASTM D7091, “Standard Practice for Nondestructive Measurement of Dry Film Thickness of Nonmagnetic Coatings Applied to Ferrous Metals and Nonmagnetic, Nonconductive Coatings Applied to Non-Ferrous Metals.”

- **Soluble Salts** – Soluble salt testing was performed using Bresle Patches and Quantab Chloride Titrator strips in accordance with SSPC Guide 15, “Field Methods for Retrieval and Analysis of Soluble Salts on Steel and Other Non-Porous Substrates.” The test involves applying a latex patch to the surface that is being tested. A known amount of demineralized water is injected into the patch, agitated and then evacuated. Two (2) milliliters of demineralized water were used for the first four tests. When all four tests were determined to be below the detectable limit, one (1) milliliter was used for the remainder of the tests. The amount of chloride in the 1 or 2 milliliters of solution is determined using titrator strips. A calculation is performed using the quantity of water used, the concentration of chlorides measured in the water (ppm) and the area tested (area of the patch), to express surface chloride concentrations in micrograms/cm^2 (µg/cm^2).

Table 1 provides a tabulation of all of the test data and visual observations taken on the bridge (see Appendix 1). The following is a summary of that data.

General Bridge Surface Conditions

The conditions listed below were found across the entire bridge with a few exceptions. The exceptions are discussed separately below and include:

- the lower laterals, chords and lower portions of the verticals and diagonals in Bays 1 and 21,
- the north top chord and deck support lateral ends,
- the underside of the corrugated decking,
- the galvanized catwalk surfaces, and
- guardrail/handrail

The general conditions that were common to most surfaces, with the exception of those listed above are as follows:

1. When evaluated in accordance with SSPC-VIS 2, "Standard Method of Evaluating Degree of Rusting on Painted Steel Surfaces," Rust Grade 9-S was observed across nearly all surfaces. This grade relates to spot rusting (S) covering less than 0.03% of the surface (Grade 9). This condition was consistent on both exterior faces and the members in the center of the bridge. In addition, no differences were observed between areas directly under the deck and at the bottom of the truss. Similarly no variations were observed in the pockets that are formed at the juncture of chords, verticals and laterals. A few notable exceptions are as follows, but they do not affect the low overall percentage of visible corrosion on the bridge:

    - Infrequent small areas of pinpoint rusting (3″ x 6″) were found at a few random locations across the bridge (SSPC-VIS 2, Rust Grade 5-P). The frequency of occurrence (a few locations per bay) was so low that it is unquantifiable.
    - Infrequent areas with more concentrated edge rusting (SSPC-VIS 2 Rust Grade 8-G). The frequency of occurrence was so low that it is unquantifiable.
    - Bay 3 Southside and Center – A few isolated areas of pinpoint rusting.
    - West Expansion Joint – Coating wear at moving components with tightly adherent superficial rust.
    - Bay 13 Southside – Some edge rusting on top flange edge of main deck girder.
    - Bay 14 Center – Some edge rusting at deck joint.

- Bay 15 Center – One lateral that has pinpoint rusting covering approximately 1% of the surface.
- Bay 15 North – One exterior diagonal has pinpoint rusting covering less than 1% of the surface.
- Bay 18 Center – Some pinpoint rusting on upper laterals covering less than 1% of the total surface area of the laterals.
- Bays 18 through 20 – Catwalk support members that have pinpoint rusting covering approximately 1% of the surface.

2. There were no particular surfaces (i.e., edges, welds, etc.) that were more prone to display the spot rusting.

3. Rust staining was observed seeping out of most fasteners.

4. There was no visible pitting or section loss observed on the bridge.

5. Examination of the substrate showed tight mill scale in all but two locations. In those two locations, tightly adherent rust was also observed.

6. When the coating was forcibly disbonded to expose the substrate, there appeared to be two layers – a top green coat and an underlying red primer.

7. There were infrequent small areas (1/8″ x 1/8″) where the topcoat(s) delaminated from the primer. These areas covered less than 0.03% of the surface.

8. A few large coating delaminations (approximately 3 to 5 square feet) were observed primarily on the main deck girder. Probing the edges of the delamination with a knife indicated fairly sound coating adhesion surrounding the disbonded coating. A listing of the coating delamination locations are as follows:

   - Bay 2 Northside – Large coating delaminations on interior of main deck girder (underside of top flange).
   - Bay 4 Center – One major delamination on the deck lateral girder.
   - Bay 7 Northside – One major delamination on the exterior web of the main deck girder.
   - Bay 10 Southside – A few large delaminations on the underside of the top flange of the main deck girder.
   - Bay 11 Northside – One major delamination on the exterior web of the main deck girder.
   - Bay 18 Southside – One coating delamination on the main deck girder top flange edge.

9. With the exception of the undersides of the structural members, surfaces located deep within structural steel pockets and heavily shaded areas (north side directly under the deck), the coating was heavily chalked (ASTM D4214: rating 2).

    - Chalk evaluations conducted on the undersides of the structural members resulted in assessments of ASTM D4214: rating 8 (little chalking).
    - Chalk evaluations conducted on shaded areas and in pockets ranged between ratings of 4 and 6.

10. Forty-four (44) of the sixty one (61) ASTM D4541 adhesion tests performed (72%) showed the coating pull-off strength to range between 300 and 500 psi. Failure generally occurred cohesively within the red prime coat.

    - Four adhesion tests (7 %) fell below 300 psi. Two of these tests were conducted on the decking (175 psi) and galvanized toe plate (200 psi) on the catwalk.
    - Ten tests (16%) ranged from 525 psi to 675psi, with 3 tests (5%) from 675psi to greater than 1000psi.

    No pattern could be detected from the adhesion test results (see Table 1, Appendix 1).

11. ASTM D3359, tape adhesion test results ranged from 0A to 5A with 34 of the 61 tests (56%) less than 2A. The following is a summary of the results:

Table 2 – ASTM D3359 Adhesion Test Summary

ASTM D3359 Adhesion	Number of Test Sites
5A	0
4A	16
3A	11
2A	10
1A	4
0A	20

12. Total system dry film thickness ranged from 3.2 to 17. 2 mils with most areas falling between 6 and 10 mils.

13. Areas of exposed primer ranged from 5.2 to 7.1 mils with adjacent total system dry film thicknesses ranging between 7.9 and 10.7 mils.

14. All 61 (100%) of the soluble salt test results fell below 0.64 ug/cm^2. Forty-three (43) of the 61 tests (70%) were below the detectable limit.

15. A few runs and sags were observed on the bridge. The frequency of occurrence amounted to no more than 3 areas per bay. The runs and sags did not affect coating performance.

Lower Laterals, Chords and Lower Portions of the Verticals and Diagonals in Bays 1 And 21

1. When evaluated in accordance with SSPC-VIS 2, a Rust Grade 7-G, was observed (general rusting covering less than 0.3% of the surface).

2. The rusting in this area appears to be a result of vandalism – impact damage from stones.

3. All other conditions reported under the general condition section are applicable to this area.

North Top Chord and Deck Support Lateral Ends

1. On the northside of the bridge between Bays 5 and 21, areas of pinpoint rusting were found on the top chord and deck support lateral ends. When evaluated in accordance with SSPC-VIS 2, Rust Grade 5-P, was observed (approximately 10% of the surface contains the pinpoint rusting).

2. All other conditions reported under the general condition section are applicable to this area.

Underside of the Corrugated Decking

1. Coating delaminations were observed on the underside of the corrugated decking in every bay on the north side of the bridge. Similar delaminations were observed on the south side between Bays 6 and 21.

2. With the exception of the north decking in Bay 12, the delaminations are intercoat between the green topcoat(s) and a gray primer. When the gray coating was probed with a knife it was determined to be tightly bonded to the substrate. Similar probing at the edges of the green coating adjacent to the delaminations resulted in poor coating adhesion.

3. In Bay 12, the coating was delaminating directly from the galvanized substrate in addition to the intercoat delamination. The exposed galvanized surface was smooth, shiny and rust free. Probing the edges of the coating adjacent to the delaminations showed poor coating adhesion.

Table 3 below provides a summary of the amount of delamination in each bay for both sides (north and south).

Table 3 – Decking Coating Delaminations

Bay	Side	Amount of Delamination
1	North	50%
	South	0%
2	North	50%
	South	0%
3	North	80%
	South	0%
4	North	90%
	South	0%
5	North	90%
	South	0%
6	North	80%
	South	10%
7	North	70%
	South	30%
8	North	30%
	South	20%
9	North	80%
	South	5%
10	North	80%
	South	10%
11	North	70%
	South	1%
12	North	80%
	South	5%
13	North	40%
	South	40%
14	North	20%
	South	10%
15	North	25%
	South	5%
16	North	1%
	South	2%
17	North	40%
	South	1%
18	North	1%
	South	0.1%
19	North	<0.1%
	South	1%
20	North	<0.1%
	South	<0.1%
21	North	<0.1%
	South	<0.1%

Galvanized Catwalk Surfaces

1. Approximately 30% of the coating has delaminated from the surface of the galvanized grating on the deck of the catwalk.

2. When the intact coating is probed with a knife, it can be easily disbonded.

3. ASTM D4541 adhesion tests conducted on the galvanized kick plate of the catwalk resulted in poor coating adhesion, 200 psi. Failure occurred between the galvanized substrate and the coating.

Guardrail/Handrail

1. Pinpoint rusting covered approximately 50% of the baluster (upright) surfaces. Where the rusting is present, the condition is comparable to an (SSPC-VIS 2: 3-P).

2. The handrail portion is approximately 30% rusted. The handrail also has significant areas (20%) where the green topcoat(s) have worn away to expose the red primer.

3. The posts and bottom rails are in fairly good condition with only a few spots of rust (SSPC-VIS 2: 9-S).

4. The guardrail exhibits spot rusting (SSPC-VIS 2: 5-S) covering 3% of the surface and some general rusting (SSPC-VIS 2: 7-G) covering 0.3% of the surface.

5. ASTM D4541 adhesion test results ranged between 300 and 375 psi. Failures occurred cohesively within both the red primer and green topcoat.

6. ASTM D3359 adhesion tests all resulted in ratings of 1A, poor.

7. When the coating is forcibly disbonded, the underlying substrate contains tight mill scale.

8. The dry film thickness of the total system ranged between 2.9 and 5.0 mils. Limited areas of exposed red lead primer were available to test. When available, the dry film thickness of the red primer ranged between 3.7 and 4.2 mils.

Appendices 2 through 8 contain photographs documenting the conditions described in the Field Investigation section above.

SAMPLES

The following samples were collected for toxic metal analysis and generic coating identification:

KTA-1: Bay 8, Southside – Underside of Upper Chord (Area w/ Pinpoint Rust)

KTA-2: Bay 8, Southside – Underside of Decking

KTA-3: Bay 13, Northside – Underside of Decking

KTA-4: Bay 3, Center – Topside of Top Flange Main Deck Support Lateral

KTA-5: Bay 4, Southside – Web of Deck Support Lateral End

KTA-6: Bay 8, Southside – Main Girder Web

KTA-7: Bay 10, Center – Web of Deck Support Lateral

KTA-8: Bay13, Center – Top Face of Top Lateral

KTA-9: Bay 20, Center – Top Face of Top Flange Lower Diagonal

KTA-10: Bay 21, Northside – Outer Face of Lower Chord

KTA-11: Bay 15, Northside – Top Face of Lower Flange Main Deck Support Girder

KTA-12: Railing, Northside East End

KTA-13: Guardrail, Northside Mid-Bridge

KTA-14: Bay 10, Northside – Top Surface of Bottom Chord at Joint (Crevice)

KTA-15: Bay 9, Northside Exterior Face of Lower Gusset Plate

KTA-16: Bay 4, Northside Outer Face of Vertical

KTA-17: Railing, Southside West End

SUMMARY OF THE LABORATORY INVESTIGATION

Infrared spectroscopy determined that the green topcoat, the red lead primer and the gray primer applied to the underside of the galvanized decking were all alkyd coatings.

Atomic absorption spectroscopy was used to measure the quantities of lead, cadmium, and chromium in ten samples of coating removed from the bridge deck truss and three samples removed from the handrail and guard rail. A full accounting of the analyses is provided in the Laboratory Investigation Section, Appendix 9, but can be summarized as follows:

1. Lead was found in all ten (10) samples of the coating removed from the bridge and all three (3) of the samples removed from the handrail and guardrail. Concentrations ranged between 4,876 ppm (0.5%) and 332,227 ppm (33.2%) with all but three samples greater than 135,611 ppm (13.6%).

2. Cadmium was only found in two (2) samples (KTA-2 and KTA-3), both from the underside of the decking. The cadmium concentration in KTA-2 was measured at 62 ppm (0.006%). The concentration in KTA-3 was measured at 128 ppm (0.013%).

3. Chromium was found in all ten (10) samples of the coating removed from the bridge and all three (3) of the samples removed from the handrail and guardrail. Concentrations ranged between 2,253 ppm (0.22%) and 49,037 ppm (4.9%), with all but two (2) samples greater than 12,906 ppm (1.3%).

DISCUSSION

In most areas, the coatings applied to the Foresthill Road Bridge are still providing excellent corrosion protection. Two areas with differing conditions, the galvanized catwalk surfaces and the guardrail/handrail are discussed separately below.

Deck Truss Surfaces

In most areas, less than 0.03% of the surfaces are rusted. A few notable, but minor, exceptions include:

1. Areas of pinpoint rusting were found on the top chord and deck support lateral ends on the northside of the bridge between Bays 5 and 21. Approximately 10% of the surface contains the pinpoint rusting. There is no evidence of section loss.

2. General rusting covering less than 0.3% of the surface of the lower laterals, chords and lower portions of the verticals and diagonals in Bays 1 and 21. The rusting in this area appears to be a result of vandalism – impact damage from rocks and stones.

3. Other isolated areas of pinpoint rusting, edge rusting and general rusting scattered at isolated random locations across the bridge. In all cases, there is no evidence of section loss or pitting.

Even areas that are typically prone to have corrosion problems on bridges (pockets that are formed at the juncture of chords, verticals and laterals) that are exposed to moist conditions were found to be similar in condition to the rest of the bridge.

While still providing corrosion protection, the coatings have degraded. The topcoat is somewhat crumbly and fragile; there is very little binder holding the coating film together. Adhesion tests (both tape and tensile adhesion) frequently result in substandard coating adhesion:

- Seventy-two percent of the tensile adhesion tests resulted in values of less than 500 psi, which is borderline at best.
- Fifty-six percent of the tape adhesion tests resulted in values of less than 2A where 4A and 5A is generally considered acceptable.

When forcibly disbonded, failure occurs within the underlying red lead primer. The remaining red lead primer is tightly bonded well to the substrate.

Inspections of the steel substrate showed that tight mill scale was present in all locations. With mill scale in place, there is always the potential for delamination when the mill scale disbonds as a result of prolonged exposure to moisture and cyclic weathering conditions. However, since the Foresthill Bridge is in a relatively dry climate, and the mill scale remains in good condition after 30 years, delamination of the mill scale may not pose a significant concern.

There are only a few areas of coating failure (delaminations) on the steel surfaces. The delaminations are very infrequent along the main deck girder.

However, there are significant areas of coating delamination found on the undersides of the galvanized decking. In most cases, the delaminations are occurring between the green topcoat and the gray primer. The delamination on the north side of the bridge is much more severe than the south side. Delaminated areas covering greater than 40% of the decking surface were commonly found in each bay on the north side. Delaminated areas on the south side were significantly less, and were only found between Bays 6 and 21. The extent of delamination was approximately 10% in all bays with the exception of Bay 13 (approximately 40%). Table 3 (page 7) provides a detailed tabulation of the amount of coating delamination for each bay of the bridge.

On the north side of Bay 12, there are a few isolated areas where the entire coating system has delaminated exposing a shiny, rust-free galvanized surface. Numerous tape adhesion tests showed that the coating is poorly bonded even where it visually appears to be intact.

Soluble salts testing showed that chlorides are present in only a few locations and at extremely low levels. All sixty-one (100%) of the soluble salt test results fell below 0.64 ug/cm^2. Forty-three of the sixty-one tests (70%) were below the detectable limit. Typically, chloride removal is not necessary until surface concentrations of 7 $\mu g/cm^2$ or greater are measured.

With the exception of the areas shaded from the sun (the undersides of the structural members, members directly under the deck and pockets formed by the juncture of several members), the coating applied to the bridge is heavily chalked. At almost all locations, the maximum chalk rating that is available under the ASTM standard was measured.

Total system dry film thickness ranged from 3.2 to 17. 2 mils, with most areas falling between 6 and 10 mils. In most areas, the dry film thickness is satisfactory for corrosion protection.

Galvanized Catwalk

The galvanized catwalk is comprised of painted galvanized grating and kick plate tack welded to steel supports. A galvanized handrail is also included in the design.

The galvanized portion of the structure is in much different condition than the remainder of the bridge. Approximately 30% of the coating has delaminated from the surface of the galvanized grating on the deck of the catwalk. The remainder of the coating is poorly bonded to the surface. Fortunately, the galvanizing is providing sufficient corrosion protection. Similar conditions were observed on the galvanized kick plate.

Guardrail/Handrail

Pinpoint rusting is prevalent on the handrail, balusters and posts. Somewhere between 30% and 50% of the surfaces contain pinpoint rusting. No section loss was observed. Major portions of the topcoat have delaminated. Adhesion of the remaining intact coating system is similar to that found on the remainder of the bridge. Tensile adhesion tests all resulted in values less than 375 psi and tape adhesion tests all resulted in ratings of 1A (poor).

RECOMMENDATIONS

Since conditions vary on the main deck truss, the catwalk and guardrail/handrail, remediation methods for each area are discussed separately.

Significant concentrations of lead and chromium were found in all of the samples tested (from the bridge truss and the handrail/guardrail). Cadmium was only found in two samples removed from the underside of the decking. The presence of cadmium in these samples is likely a result of specs of galvanizing in the coating samples.

Because of the presence of lead, surface preparation operations will have to be accomplished in accordance with OSHA and EPA regulations and within a containment system to protect the public, environment, and workers. Full containment and ventilation will be required for any abrasive blast cleaning operations. If only spot repairs are performed, it might be possible to avoid full containment by using power tools with vacuum attachments and HEPA filtration. However, the pressure washing that should be performed in conjunction with power tool cleaning will necessitate the use of containment to collect the water and paint debris, but this might be mitigated by conducting localized solvent cleaning of the areas by hand instead of pressure washing.

Project waste will have to be collected, tested, and disposed of in compliance with the applicable hazardous and non-hazardous waste regulations. While a number of federal regulations apply, at a minimum, specific attention needs to be paid to the OSHA Construction Industry Lead Standard, 29 CFR 1926.62 for worker protection, and EPA regulations 40CFR 260-268 for waste handling and disposal. Specific California regulations will also apply.

The lead regulations would be applicable to both of the repair methods described below.

Deck Truss Surfaces

Three options are available for addressing the coating issues on the deck truss. The first involves complete removal; the second would include just spot repairs; and the third option would involve postponing any maintenance until a later date.

Option 1 – Complete Coating Removal

Under this option, complete coating removal by abrasive blast cleaning to SSPC-SP 10 "Near White," is required for all steel surfaces. As an alternative to control dusting, wet abrasive blast cleaning or water jetting with abrasive injection could also be considered, as long as all mill scale, rust, and old paint are completely removed.

The prepared surfaces should be coated with a conventional organic zinc/epoxy/urethane system. The recommended coating system is multi-functional. The organic zinc provides corrosion protection. The intermediate epoxy serves as a barrier coat and the urethane finish provides UV resistance.

The underside of the galvanized decking should also be abrasive blasted to remove the coating and to roughen the surface. However, efforts should be made to allow as much of the galvanizing to remain as possible. Reducing the blast pressure, using smaller less aggressive blast media and standing back from the surfaces are all methods that can be used to preserve the galvanized layer.

The prepared galvanized surfaces can then be spot repaired with an organic zinc primer in areas where the galvanizing has been worn away. The entire surface can be overcoated with an epoxy primer and finished with a urethane topcoat.

If the complete removal option is elected, a service life of at least 40 years could be expected. In addition, this option would be ideal if the repainting work is done in conjunction with the seismic retrofit.

The cost for performing the complete coating removal and replacement option is approximately $20,000,000.00[2]. With this option, spot repair is expected to be required in 20 years. After 35 years, spot repair and overcoating would be required. The average equivalent annual cost of this approach for a 40-year period is approximately $2,250,000.00.

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[2] KTA's estimated costs run from $16.50 to $20.00 per square foot. This is considerably lower than the actual costs that have been proposed by CalTrans. The reason for the difference may be the result of (1) the crew size that was assumed when preparing the estimate and/or (2) the amount of overtime used in the estimate. KTA assumed that a large crew with multiple blasting rigs would be used so that the work could be completed in one season. If the work is to be performed with a smaller number of crews in multiple years, the cost would be increased. Similarly, KTA assumed only ten hours of overtime per week. If extended hours are typically encountered on CalTrans projects costs can be expected to increase.

This option is the most costly option; however, it makes sense to select complete coating removal and replacement because of the following reasons:

1. A seismic retrofit is going to be done, so by scheduling the painting in conjunction with that effort, the public can avoid an additional disruption in ten years after the seismic work on the bridge is completed.

2. The coating work can be coordinated so that the lead is removed prior to cutting, torching and welding so that those operations can be completed without the necessity for lead abatement practices during the retrofit. Significant savings could be expected.

3. If complete coating removal and replacement is elected, the possibility of spontaneous intercoat disbonding with chips falling from the bridge can be eliminated. This often occurs as bridge coatings age.

It is important to note that the proposed coating systems have all been tested under the National Transportation Product Evaluation Program (NTPEP) and approved by the Northeast Protective Coatings Committee (NEPCOAT). These systems have been successfully used for over twenty years on bridges across the country. Major structures include most of the east coast bridges including the Benjamin Franklin Bridge in Philadelphia, Pennsylvania, and the George Washington Bridge, Verrazano Narrows Bridge and many other bridges in the New York Metropolitan area. Painting of the Benjamin Franklin Bridge started 10 years ago and the system is performing well.

Option 2 – Spot Repair

Spot repairs alone can be used to prevent worsening of the existing corrosion. With this option, pressure water cleaning would typically be used to clean the surfaces requiring repair. However, since pressure water cleaning could be cost prohibitive due to the need to collect the wastewater, localized cleaning in accordance with SSPC-SP 1, “Solvent Cleaning,” is also a consideration. SSPC-SP 1 cleaning would entail hand cleaning with detergent and degreasers.

On all steel surfaces except the top chord and deck support lateral ends on the northside of the bridge between Bays 5 and 21, power tool cleaning in accordance with SSPC-SP 15 would be used to prepare the rusted areas, to remove nearly all rust, mill scale and coatings. All edges of existing, intact coating should be feathered smooth.

A surface tolerant epoxy (epoxy mastic) would then used to spot prime the prepared bare steel, overlapping onto the existing feathered edges. A finish coat of polyurethane can then be spot applied to the primed surfaces.

On the surfaces that contain prevalent pinpoint rusting along the top chord and deck support lateral ends on the northside of the bridge between Bays 5 and 21, complete removal and coating replacement is necessary. The coating system specified for complete coating replacement would be applied in this area. Power tool cleaning would be too time consuming to prepare this large surface area. Open abrasive blasting in accordance with SSPC-SP 10 would be more cost effective for this application.

The undersides of the galvanized decking would be treated as described above. Spot repair of the galvanized decking is not an option since the coating are poorly bonded and the pressure water jetting is likely to remove a good portion of the existing coatings.

With this option, the service life of the coating can be extended another seventeen years, keeping in mind that additional maintenance may be required over that period, and complete coating replacement may be necessary after ten years or so. Maintenance should be expected if there is a desire to have a bridge that is free of all visible rust, as it is likely that areas of moderate deterioration will escape detection during the touch-up process, only to reveal themselves years down the road as the surfaces continue to weather.

The disadvantage of this approach is that there will be slight differences in color and gloss where the spot repairs are performed.

Test patches should be prepared to assure that if the epoxy lifts the edges of intact coating, that it can be removed by scraping and repaired to achieve sound adhesion. The test patches will also help to determine whether it is possible to feather the repair areas to sound coating, which is a particular concern due to the poor adhesion of the existing system.

The costs for performing the spot repair option are expected to run around $1,800,000. With this option complete coating removal and replacement is expected to be required in 17 years with spot repair in 37 years. This amounts to an average equivalent annual cost of around $990,000 over a 40-year period.

Option 3 – No Action

The coatings applied to the bridge are in good enough condition that remediation work could be postponed for at least another ten years. As discussed above, there is only minor surface rusting found on the bridge. The entire coating system is in place with the exception of (1) a few isolated areas on the bridge structural members and (2) the underside of the corrugated decking. At these locations, there was no evidence of rusting.

Given the relatively dry northern California environment, the existing rusting would not significantly worsen over the ten-year period. Another assessment could be performed after ten years and the condition could be re-evaluated. Once remediation is required, complete coating removal and replacement would be necessary.

If no remediation activities are performed at this time, complete coating removal and replacement would be required in another ten years. Spot repair will be needed in thirty years. This amounts to an average equivalent annual cost of around $1,194,000 over a 40-year period.

Spot Repair and Overcoating – Not Recommended

KTA strongly recommends against spot repair and overcoating as a viable option for painting the bridge. The existing topcoat and the top layer of the red lead primer are weak and fragile. Pressure water jetting would have to be used to remove all loose coating. Adhesion testing conducted on the bridge during the field investigation has shown that the jetting operations would likely leave a layer of red lead primer behind. As determined during the field investigation, this layer is smooth and hard. Adhesion of the new coating to this layer would likely be poor.

In addition, the outcome of the pressure water jetting process is often varied as the amount of coating removed is extremely operator-dependent. Frequently fragile topcoats will be left behind that will result in coating delamination within a year or so of overcoating. Tests to assure that all of the necessary coating has been removed (probing with a dull putty knife) are subjective and 100% of the surface cannot be tested to determine compliance.

Finally, the surface of the steel is covered with mill scale. Aged mill scale is prone to disbondment. While there were little signs of lifting mill scale to date, and the dry climate is not conducive for it to occur, it is still a possibility that needs to be recognized. The SSPC-SP 10, "Near White Metal Blast Cleaning," specified for the complete coating replacement option, will completely remove the mill scale, eliminating any possibility of future detachment.

Environmental Considerations

During the coating condition assessment, heavy public use of the areas below the Foresthill Road Bridge was observed. As previously mentioned, laboratory analysis of the existing coating system indicated detectable concentrations of lead, cadmium, and chromium. Based upon these two items, high volume ambient air monitoring for TSP-lead is recommended if complete coating removal is the chosen maintenance option. High volume ambient air monitoring is typically performed during all dust producing activities in areas of potential environmental/public impact to verify that the surrounding public and environment are not adversely impacted by project activities, and to verify that the containment system is adequately controlling emissions.

Additionally, pedestrian walkways are located along both the eastbound and westbound lanes of the Foresthill Road Bridge. Based on observations made during the coating condition assessment, it is evident that both walkways are heavily used by the public. Closure of the pedestrian walkways during paint removal activities is recommended in order to limit the potential safety and health concerns of the public. If closure of the walkways is not feasible, area air monitoring using personal sampling pumps should be considered during surface preparation activities.

Galvanized Catwalk

The existing paint is poorly bonded probably as a result of improper surface preparation prior to the original painting process. Galvanized steel can be very smooth thereby preventing sound coating adhesion unless special cleaning and preparation steps are performed.

Attempts to repaint the existing grating would result in incomplete coverage since the grating has many sharp edges and is complex. Coating flows away from the sharp edges and the complexity of the surface will make complete coverage very difficult. Over time as the galvanized surface wears away, rust will become prevalent. In addition, repainting would be costly.

Remediation of the delaminating and poorly bonded coatings applied to the galvanized grating can be best be accomplished by complete replacement of the grating. The galvanized surfaces should be left uncoated. Galvanizing in the northern California climate will last for many years without the formation of red rust.

The galvanized kick plates and railings can be lightly abrasive blasted to remove the poorly bonded coating, while attempting to leave as much of the galvanized layer behind as possible. Specialized abrasive blasting techniques will be necessary in order to assure that the galvanized layer is preserved.

The properly prepared surfaces can then be spot repaired with an organic zinc primer in areas where the galvanizing has been worn away. The entire surface can be overcoated with an epoxy primer and finished with a urethane topcoat.

Guardrail/Handrail

The rusting is significant enough on the guardrail and handrail that complete coating removal is the only option. Generally, when coating defects cover 10% to 15% of the coated surface or more, the cost effectiveness of repair must be questioned. The amount of rusting on the handrail/guardrail ranges from 30% and 50% of the total surface.

The degraded coatings on the guardrail/handrail should be abrasive blasted identical to the requirements of the complete coating replacement option on the deck truss portion of the bridge. Similarly, the three-coat organic zinc/epoxy/urethane system should be applied.